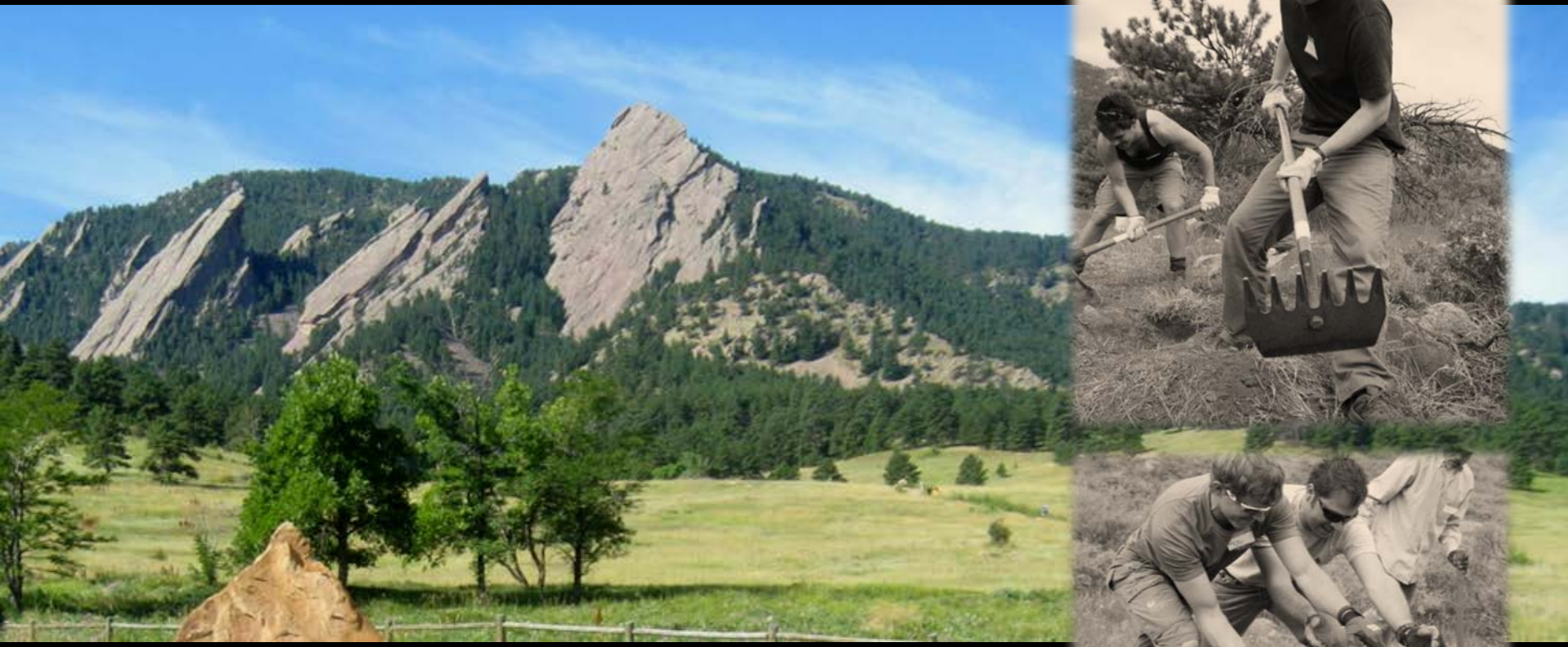
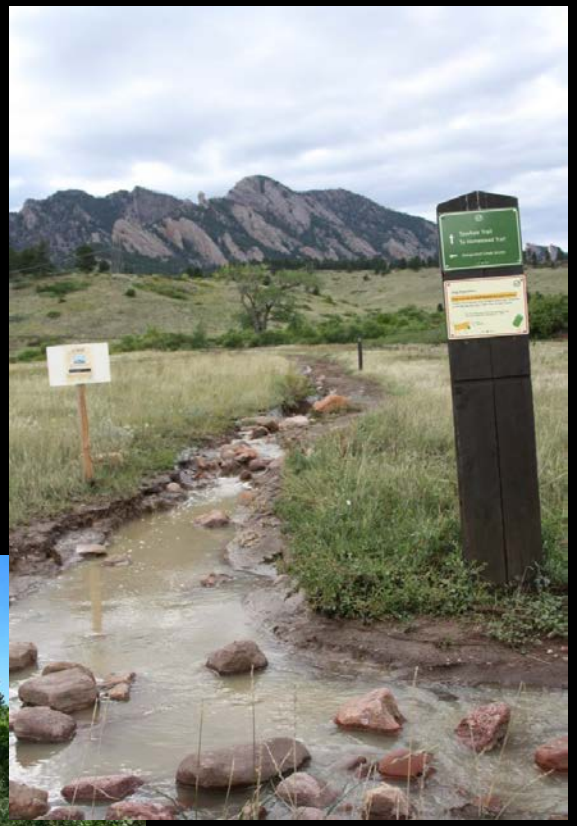
2013 Flood and Trail Sustainability



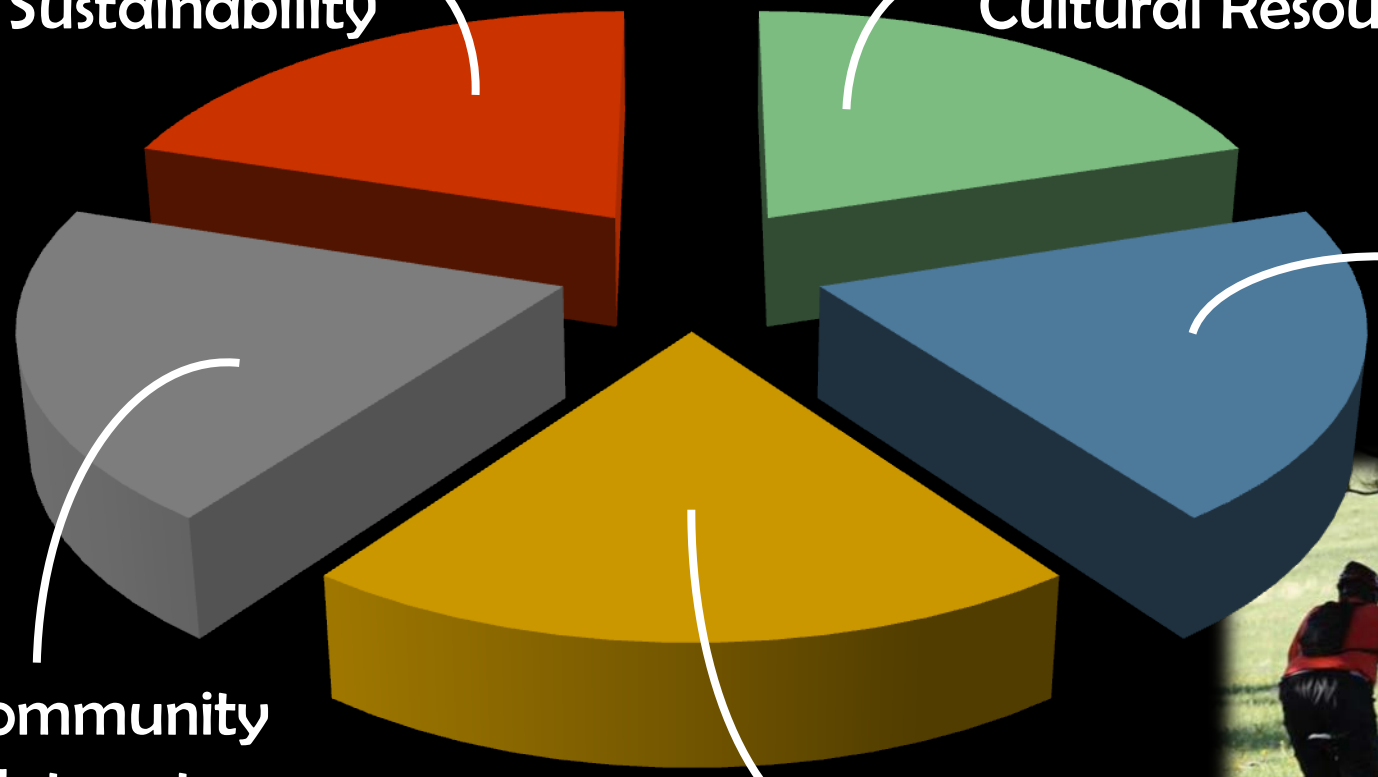
2013 Flood

A rare and extreme event gave us the opportunity to observe:

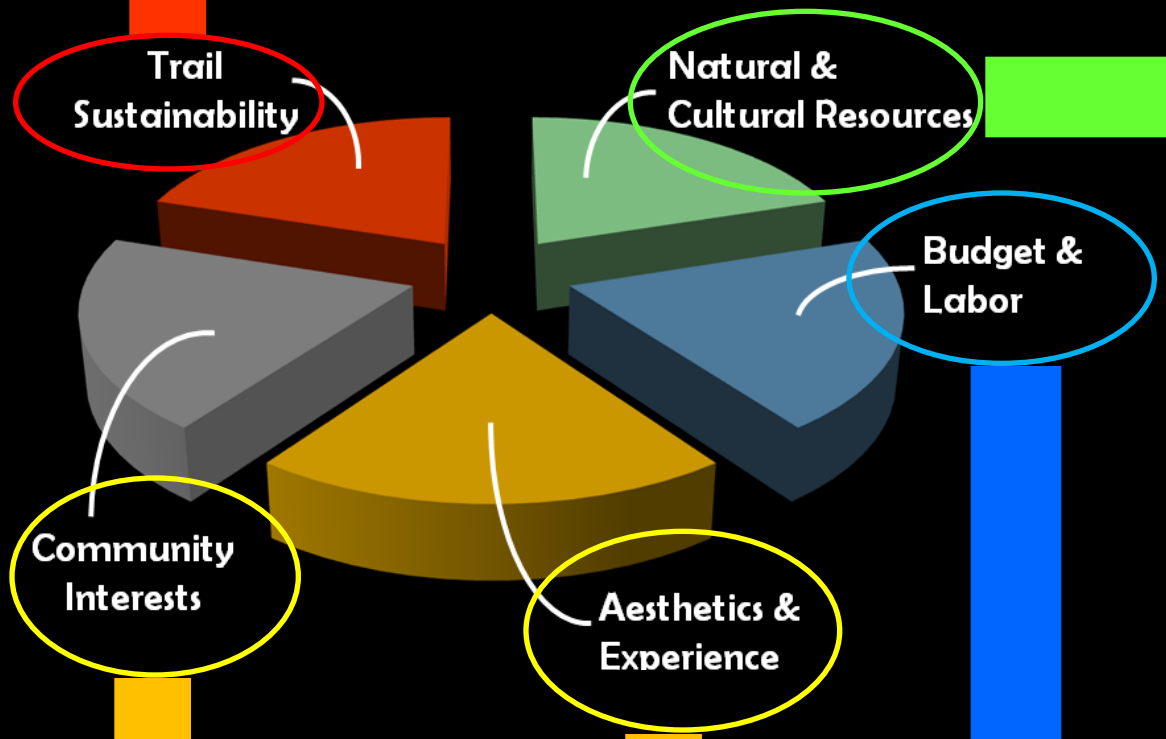
- What trails survived the flood with little to no damage, and <u>why</u>?
- What trails were extensively damaged, and <u>why</u>?



A Multi-Disciplinary Look at Trail Design:



The primary focus of this presentation, but to touch base on the others…



Incorporating natural resource protection into trail alignment and construction techniques.

Trail alignments that do not meet sustainability criteria can increase 50-year lifecycle costs by 5x to >20x!

Incorporating community interests, user group requirements (e.g. hikers, mtn bikes, equestrians), and aesthetics into design criteria.

The Role of the Trail Designer

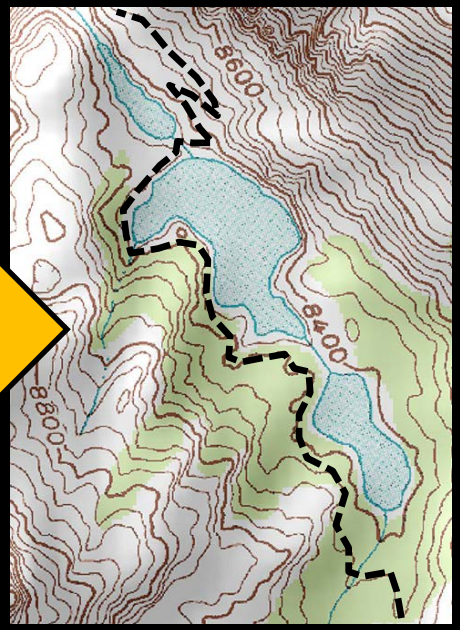
Trail Sustainability

Natural / Cultural Resources

Budget / Labor

Aesthetics / User Experience

Community Interests



Trail Design & Management Guidelines Matrix

		X-Slope Range	Tread Width	Max. Sustained Grade	Max. Sustained Outslope	Clearing		Turn Radius	Surface Materials					
						Width	Height		Natural	Gravel	Crusher	Roadbase	Concrete	Asphalt
Accessible		0-50%	>=3'	8.33%	<2%	8'	8'	4'	ok	No	ok	ok	ok	ok
Class 5 *Fully Developed*	Hiking	0-30%	3-5'	8%	<=5%	6'	8'	2'	ok	ok	ok	ok	ok	ok
	Biking	0-30%	3-8'	8%	<=5%	10'	10'	6'	No	ok	ok	ok	ok	ok
	Equestrian	0-30%	3-8'	8%	<=5%	10'	10'	8'	No	ok	ok	ok	No	No
	Official Vehicle	N/A	*8-10'*	8%	<= 8%	28-40'	12'	10-12'	No	ok	ok	ok	ok	ok
Class 4 *Highly Developed*	Hiking	0-50%	2.5-5'	10%	<=5%	6'	8'	2'	ok	ok	ok	ok	No	No
	Biking	0-50%	3-8'	8%	<=5%	6-10'	10'	6'	ok	ok	ok	ok	No	No
	Equestrian	0-50%	3-8'	8%	<=5%	6-10'	10'	8'	ok	ok	ok	ok	No	No
	Official Vehicle	N/A	*8-10'*	6%	<= 6%	28'	12'	10-12'	No	ok	ok	ok	ok	ok
Class 3 *Developed/ Improved*	Hiking	0-75%	1.5-3'	15%	<= 8%	4-6'	8'	2'	ok	ok	ok	ok	No	No
	Biking	0-75%	1.5-5'	12%	<=5%	4-6'	10'	6'	ok	ok	ok	ok	No	No
	Equestrian	0-75%	1.5-6'	12%	<=5%	6'	10'	8'	ok	ok	ok	ok	No	No
	Official Vehicle	N/A	*8-10'*	6%	<=5%	12'	10'	10-12'	ok	ok	ok	ok	No	No
Class 2 *Minor Development*	Hiking	0-75%	1.5-2.5'	15%	<=10%	4'	8'	2'	ok	No	No	No	No	No
	Biking	0-75%	1.5-3'	12%	<= 8%	4-6'	10'	6'	ok	No	No	No	No	No
	Equestrian	0-75%	1.5-2.5'	12%	<= 8%	6'	10'	8'	ok	No	No	No	No	No
	Official Vehicle	N/A	*8-10'*	5%	<=5%	10'	10'	10-12'	ok	N/A	No	No	No	No
Class 1 *Primitive/ Undeveloped*	Hiking	0-90%	1.5-2'	15%	<=10%	N/A	N/A	2'	ok	No	No	No	No	No
	Biking	0-90%	1.5-2'	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	N/A	N/A
	Equestrian	0-90%	1.5-2'	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	N/A	N/A
	Official Vehicle	N/A	*8-10'*	4%	<= 3%	N/A	N/A	10-12'	ok	N/A	No	No	No	No
Class 0	All	N/A	0-2'	N/A	<=15%	N/A	N/A	N/A	ok	No	No	No	No	No

Trail Design Parameters provide guidance for the assessment, survey and design, construction, repair and maintenance of trails, based on the Trail Class and Designed Use of the trail.

Exceptions and variances to these parameters can occur when site-specific circumstances demand such exceptions. These exceptions should be noted in the TMO for the trail.

* Accessible is currently a separate Trail Class. If assessing/designing trails for accessibility, refer to current Agency trail accessibility guidance.

Finalized 12/04/07

What is Trail Sustainability?

- Support current and future uses
- Minimal impact to natural systems
- Negligible soil loss
- Requires little re-routing and minimal maintenance over extended time

What is sustainability?

Sustainability of natural surface trail corridors is defined as the characteristic of a travel surface to support currently planned and future uses with minimal impact to the natural systems of the area. Sustainable trails have negligible soil loss or movement while allowing the naturally occurring plant systems to inhabit the area, recognizing required pruning and eventual removal of certain plants over time. Sustainable trails will not adversely affect the naturally occurring fauna. Sustainable trail design will accommodate existing and future uses while only allowing appropriate uses. The sustainable trail will require little rerouting and minimal maintenance over extended periods of time.

Developing Sustainable Mountain Trail Corridors
National Park Service, Rocky Mountain Region, 1991

Trails that Survived the Flood:

- No perceptible soil loss
- Damage only in areas with high flood water
- Met sustainability criteria:
  - Gentle trail grades relative to cross-slope
  - Grade reversals

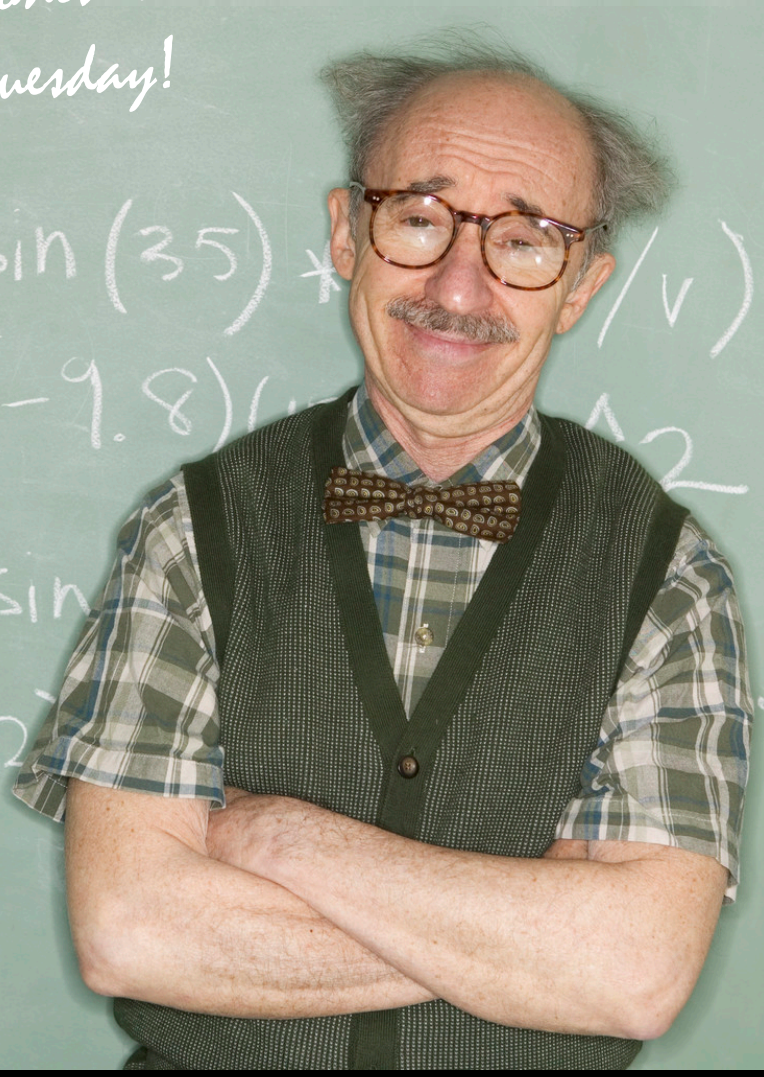
Trails that Failed During the Flood

- Erosion gullies: from a few inches to several feet deep
- Large depositional areas covering vegetation
- Did not meet sustainability criteria:
  - Steep trail grades relative to cross-slope
  - Existing erosion issues
  - Numerous prior attempts at “fixes”: waterbars and check steps

Trail Design 101

No cell phones in class.

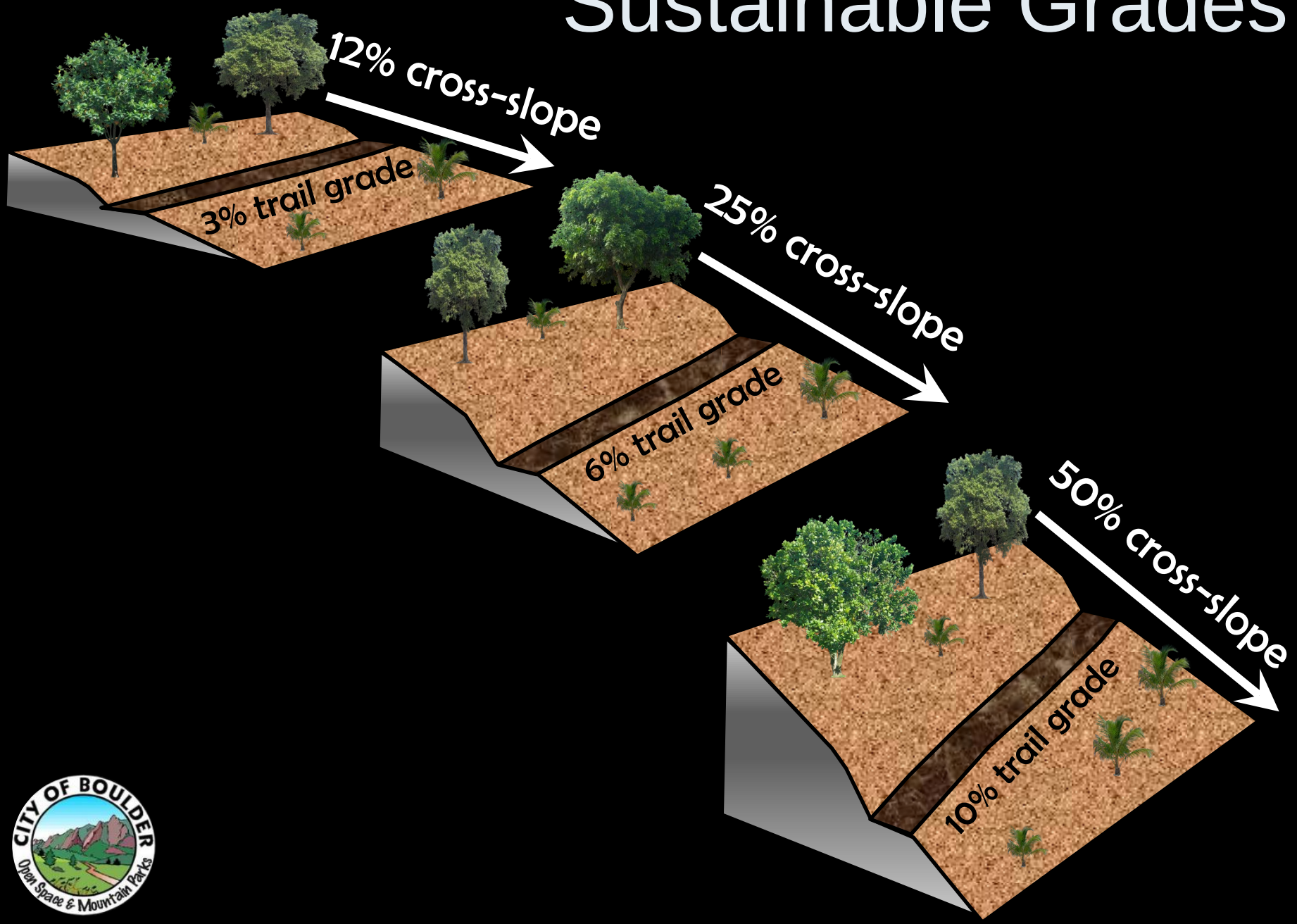
Quiz on Tuesday!



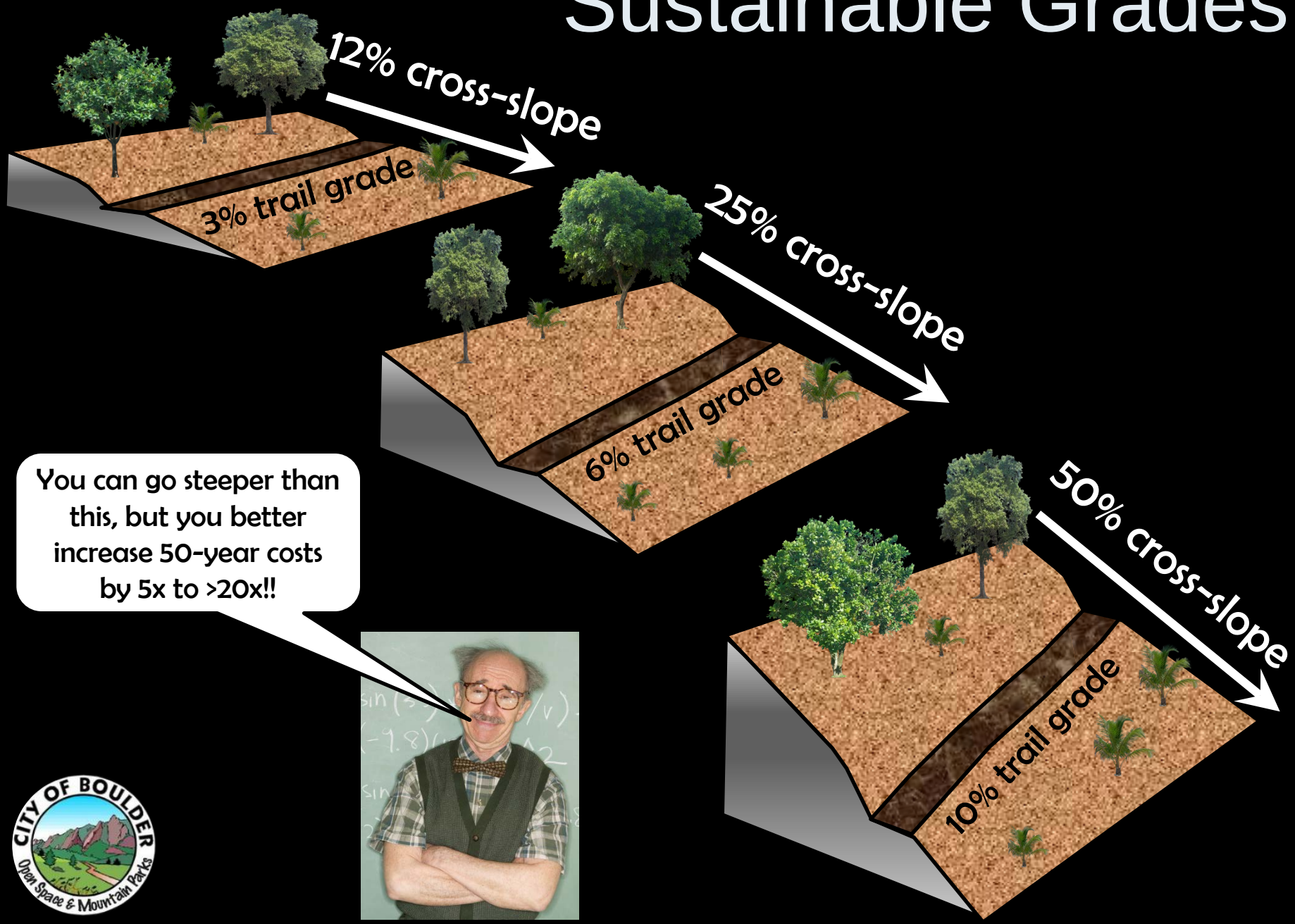
Today's Class:

- Sustainable trail grades!
- Contour trails!
- Grade reversals!

Sustainable Grades



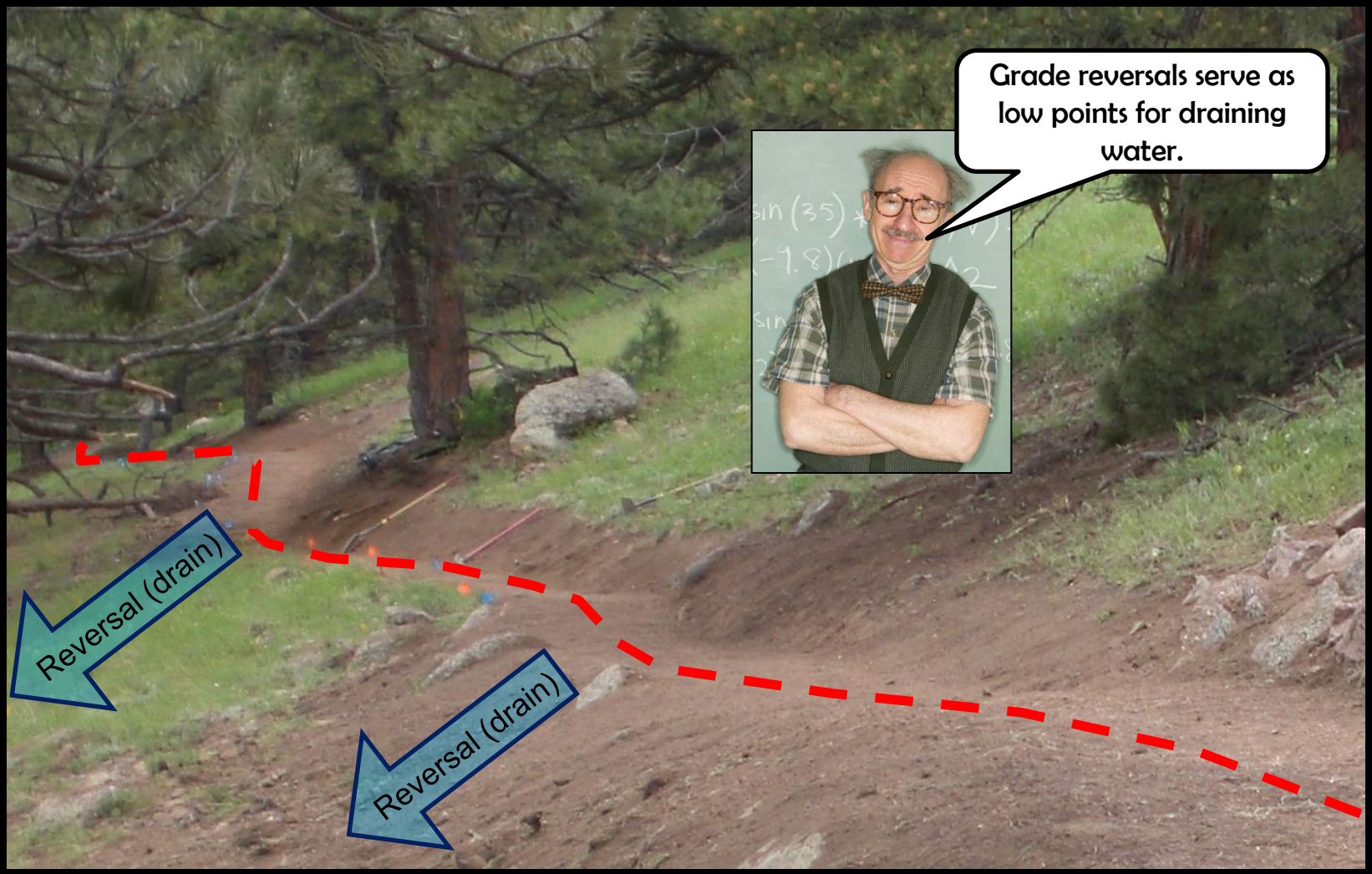
Sustainable Grades



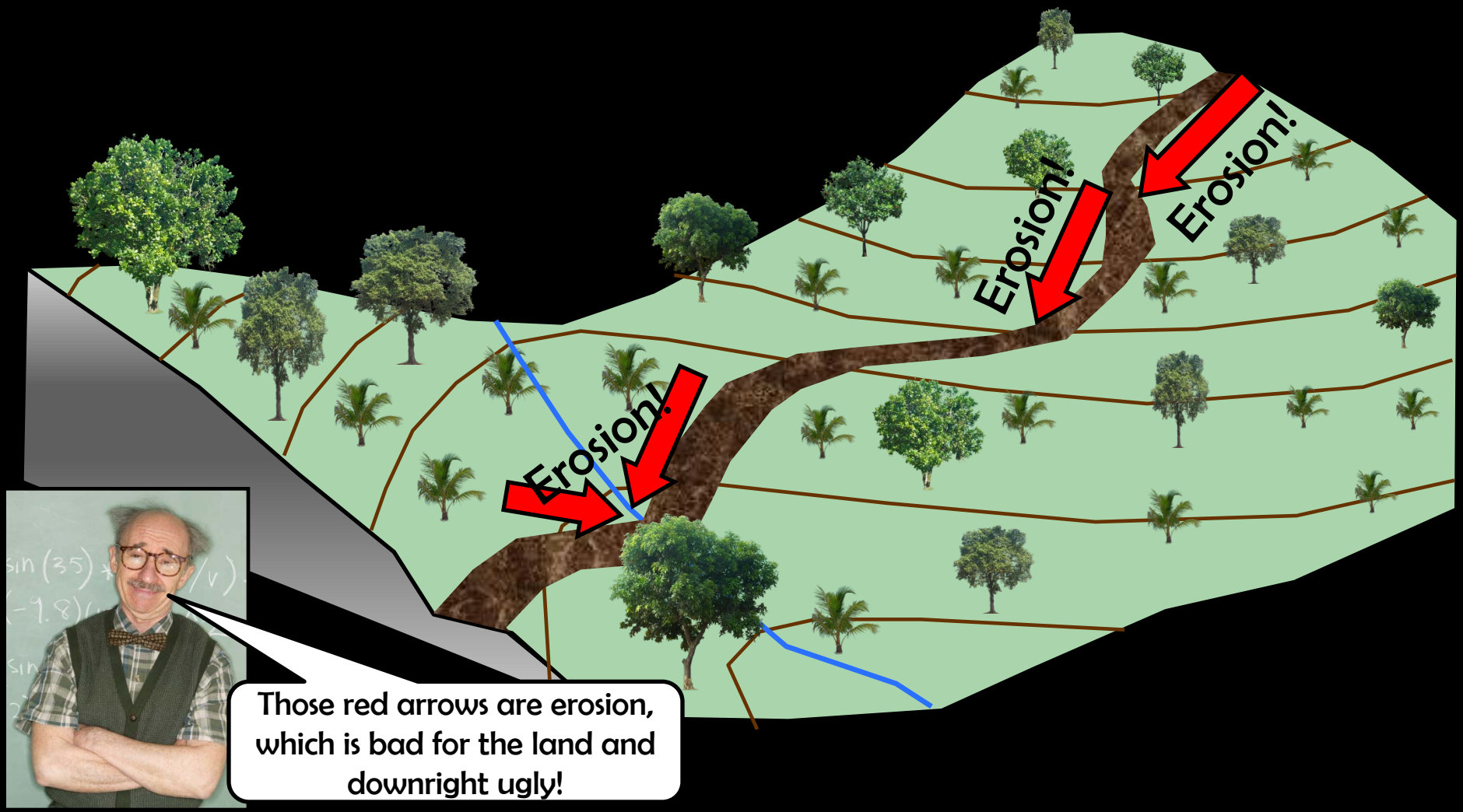
You can go steeper than this, but you better increase 50-year costs by 5x to >20x!!

CITY OF BOULDER
Open Space & Mountain Parks

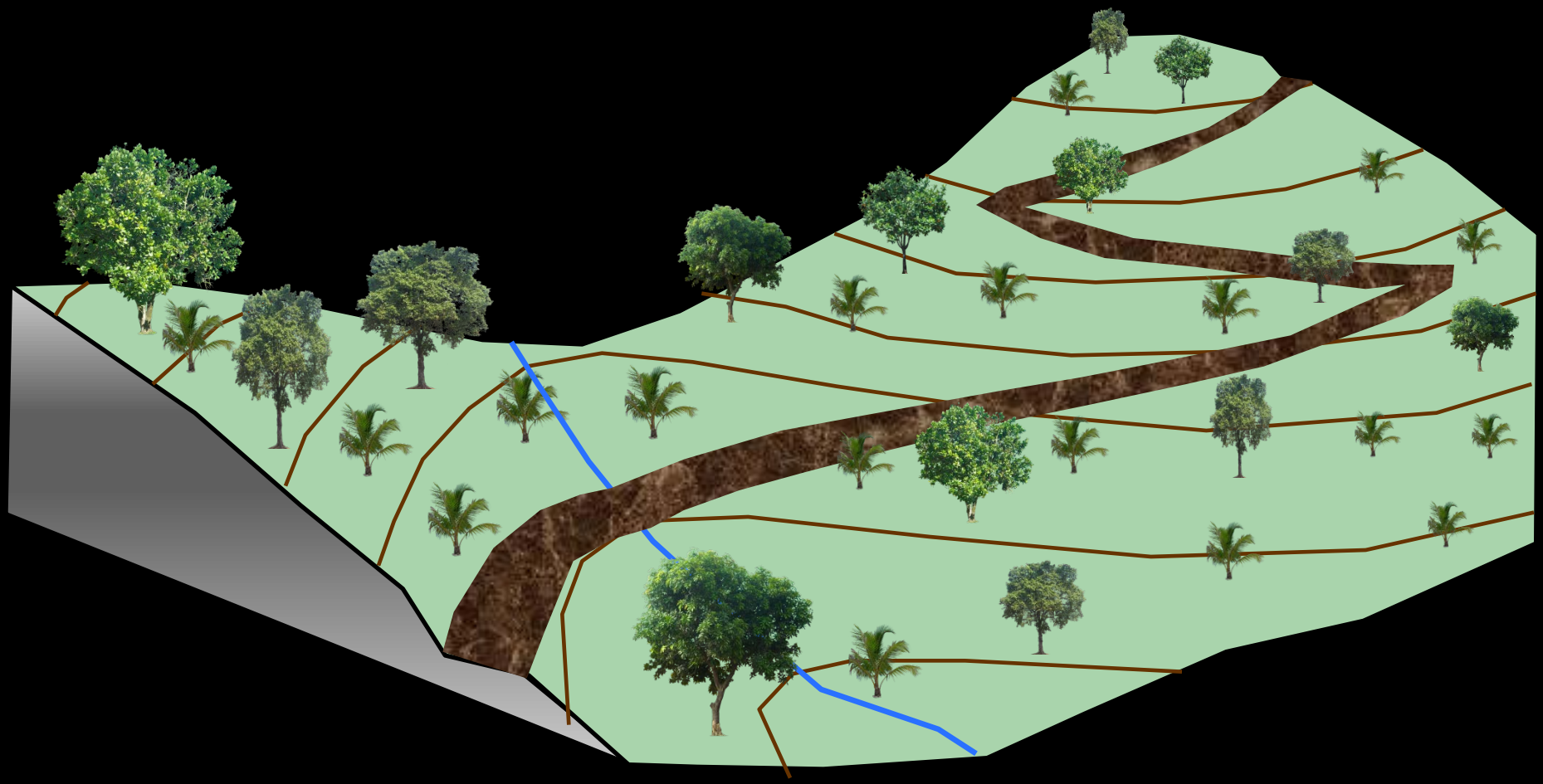
Grade Reversals



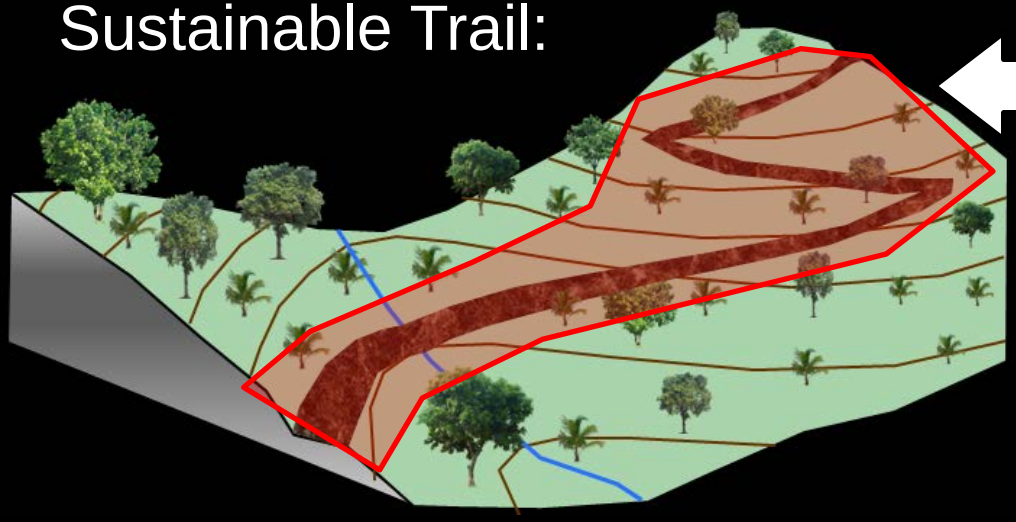
Steep Fall-Line Trails: Bad!



Contour Trails: Sustainable!

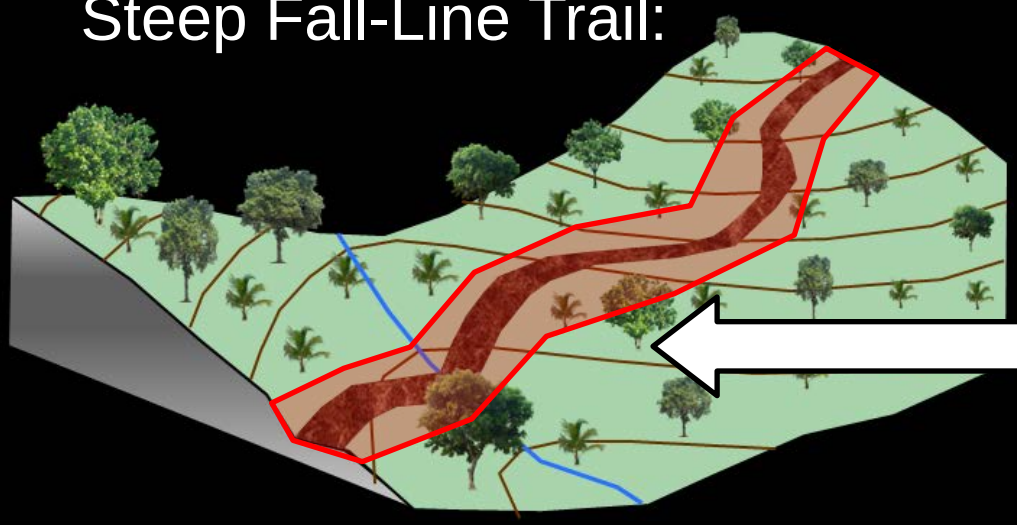


Sustainable Trail:

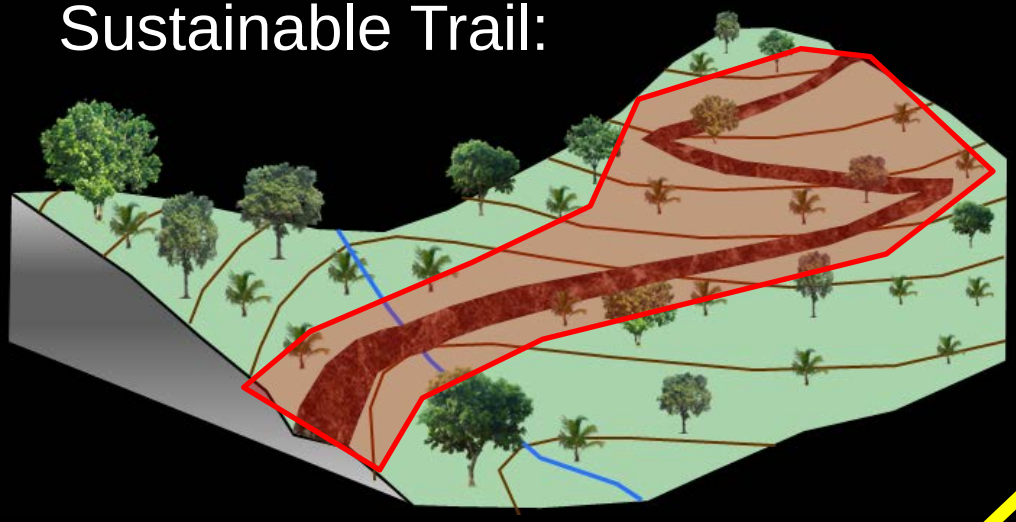


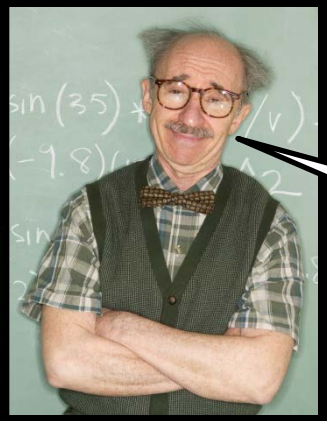
But, isn't THIS worse for the land because it takes up more acreage than THIS?

Steep Fall-Line Trail:



Sustainable Trail:

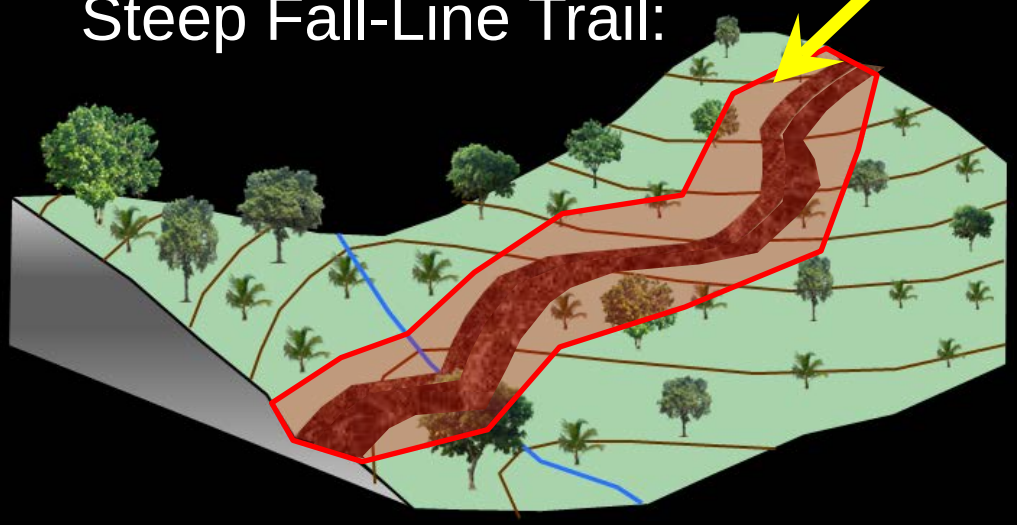




NO! Because fall-line/steep trails...

- Get eroded, wide and braided.

Steep Fall-Line Trail:



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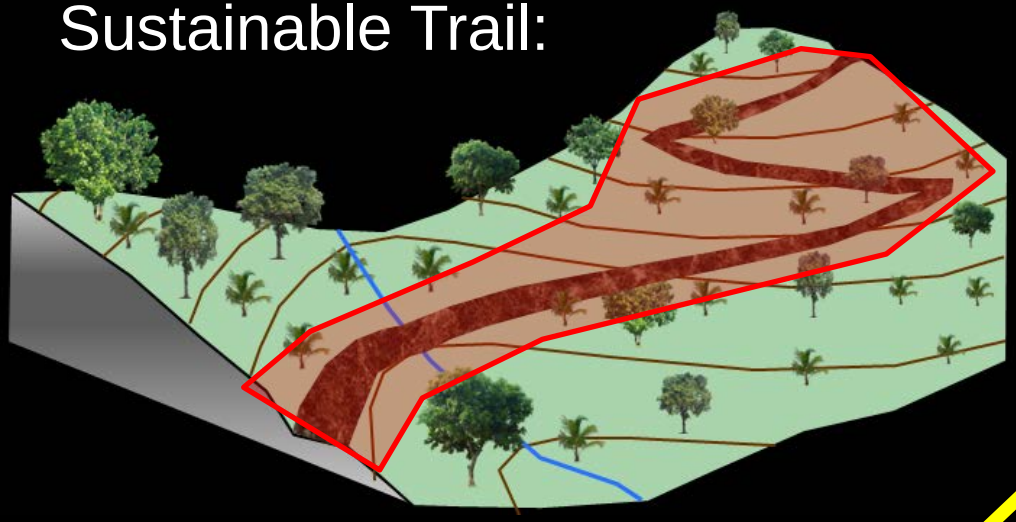

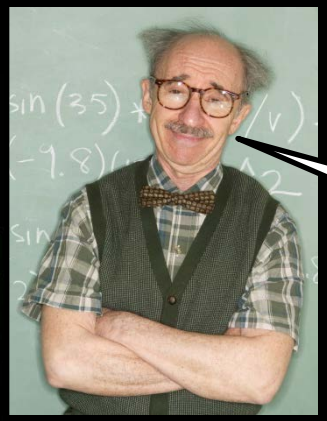

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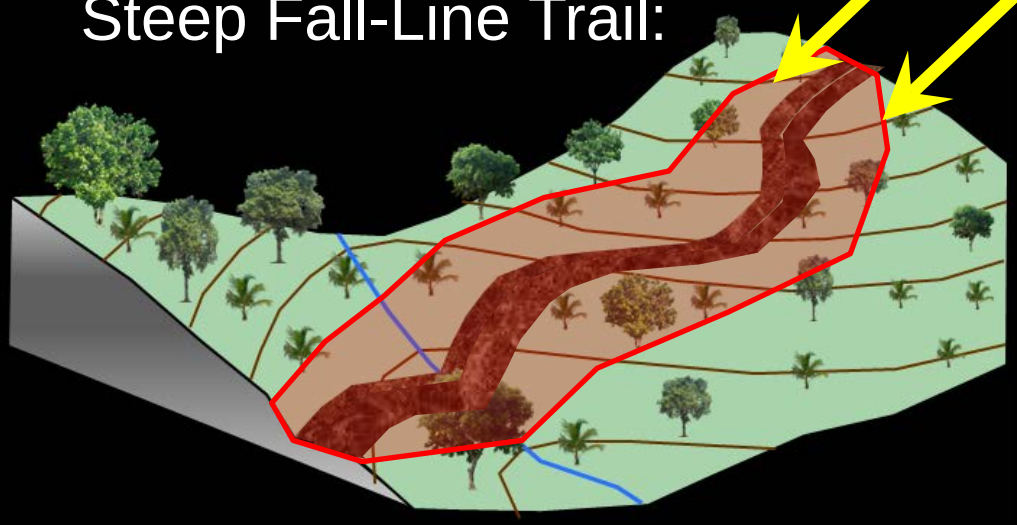
- Get eroded, wide and braided.
- Require repeated construction impact due to frequent repairs.

Steep Fall-Line Trail:



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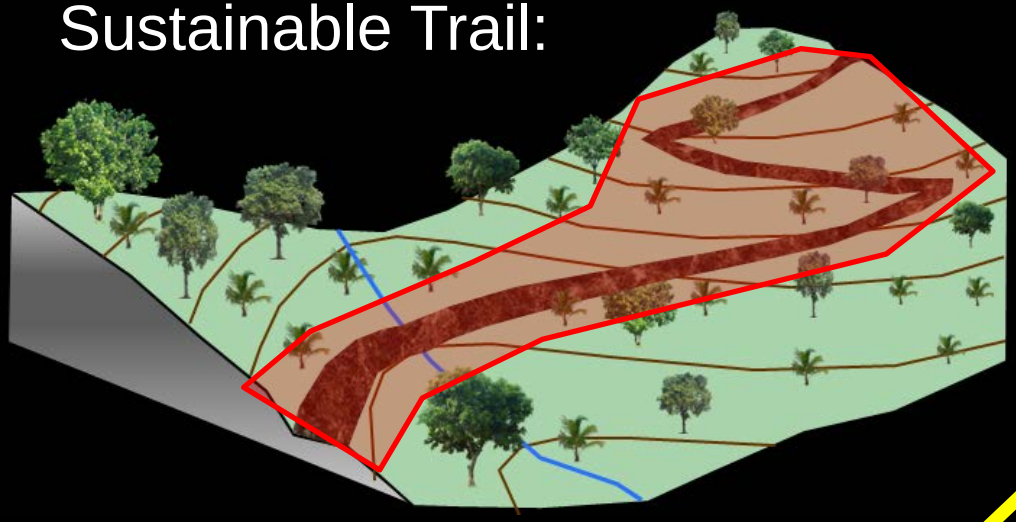
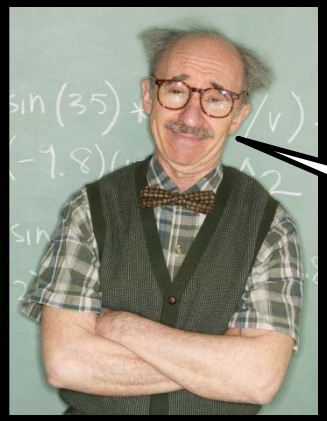
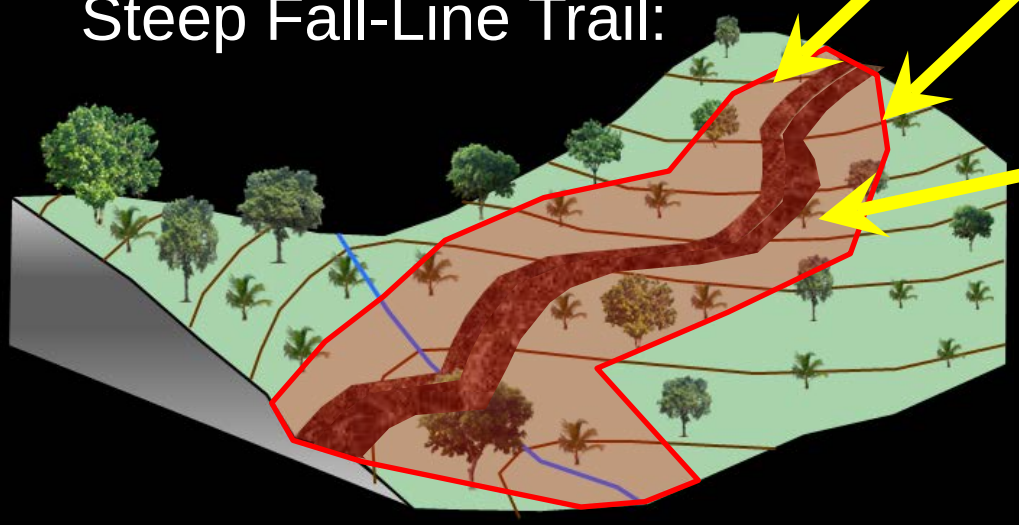




NO! Because fall-line/steep trails...

- Get eroded, wide and braided.
- Require repeated construction impact due to frequent repairs.
- Result in off-trail impacts from sedimentation.

Steep Fall-Line Trail:



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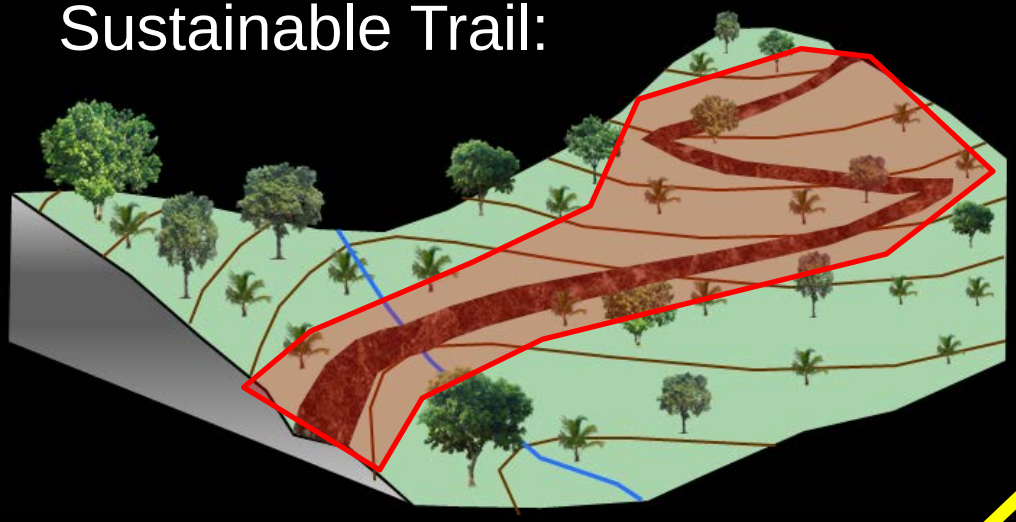

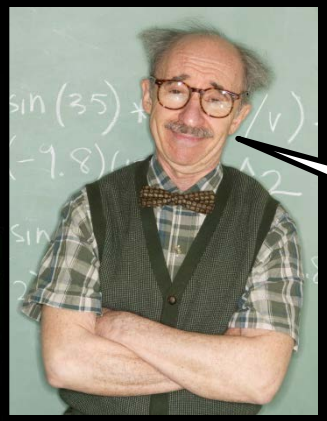

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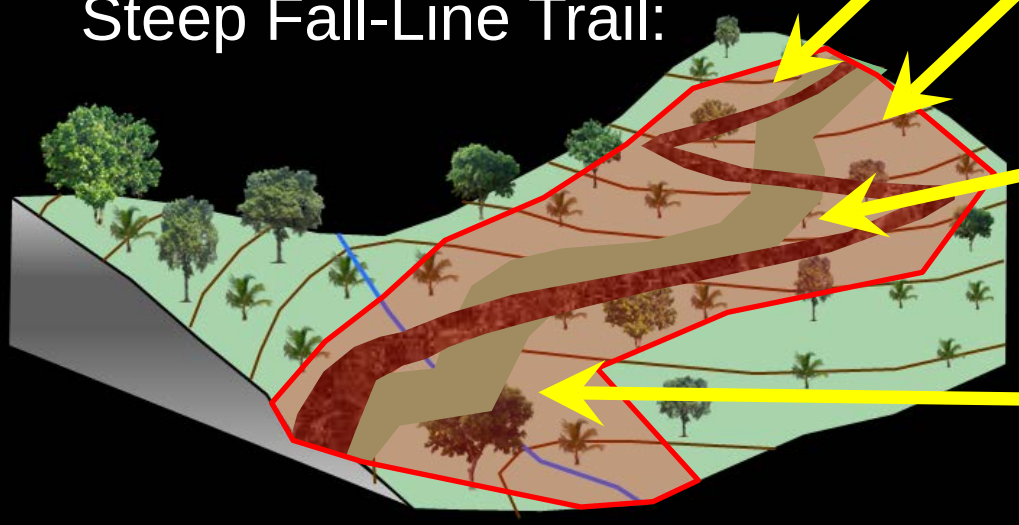
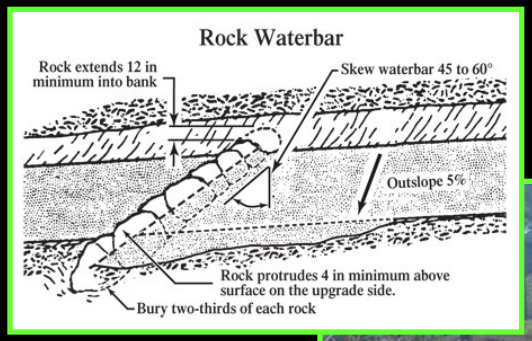


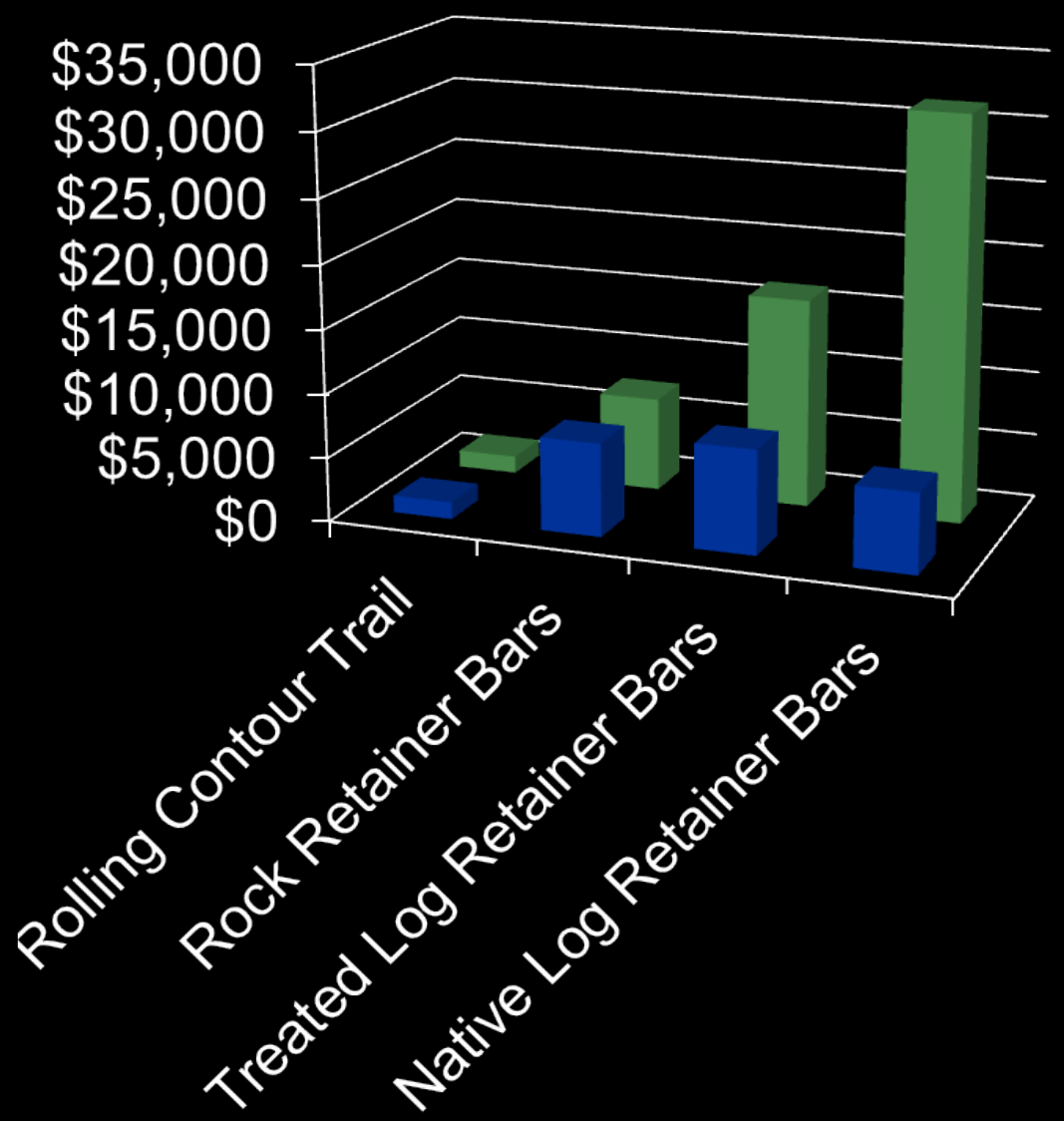
- Get eroded, wide and braided.
- Require repeated construction impact due to frequent repairs.
- Result in off-trail impacts from sedimentation.
- Likely require re-routing long-term anyway.



OSMP recognizes that some trails need to be steep!

- E.G. Some summit-access trails and climbing access trails
- Steps and waterbars require <u>very high</u> investment over time!...

RMNP: Investments analyzed over the trail's life cycle



- Initial Construction Costs
- 50-Year Lifecycle Cost

Item	Initial Construction Costs*	50-Year Lifecycle Cost*
Rolling Contour Trail	$1350	$1350
Rock Retainer Bars	$7310	$7310
Treated Log Retainer Bars	$8160	$16,320
Native Log Retainer Bars	$6290	$31,450

* Based on 50 linear feet of trail

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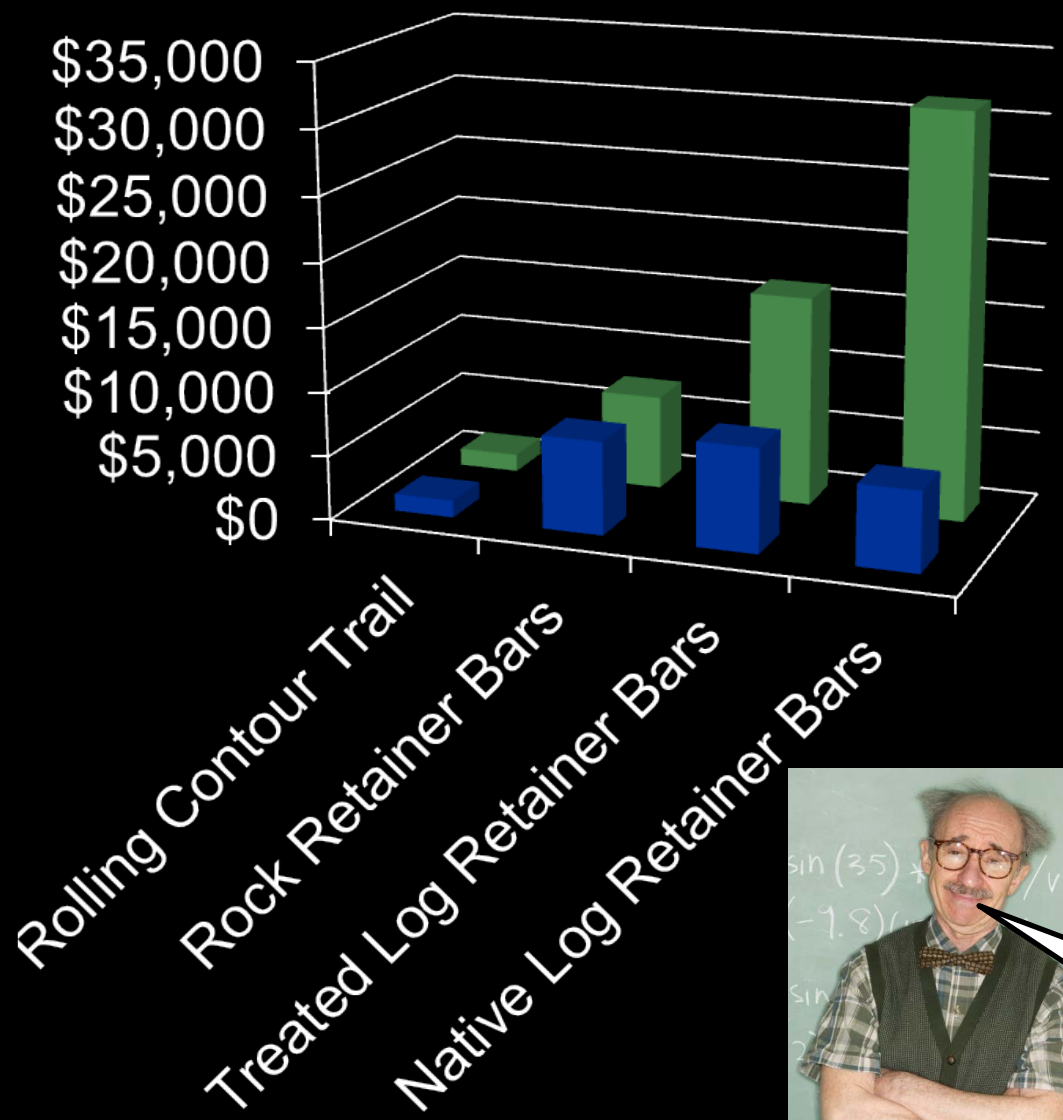

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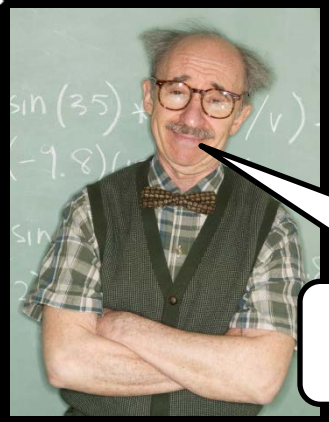
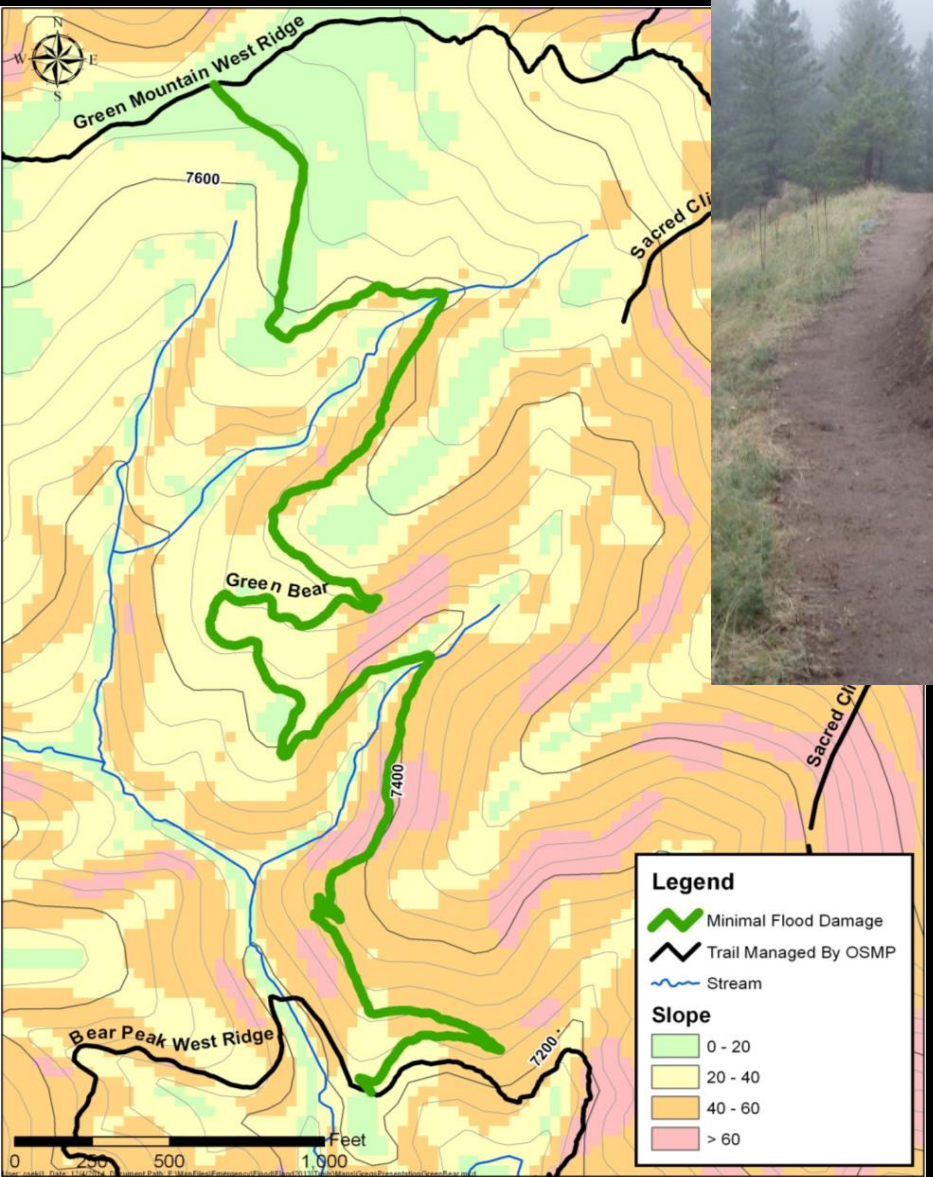


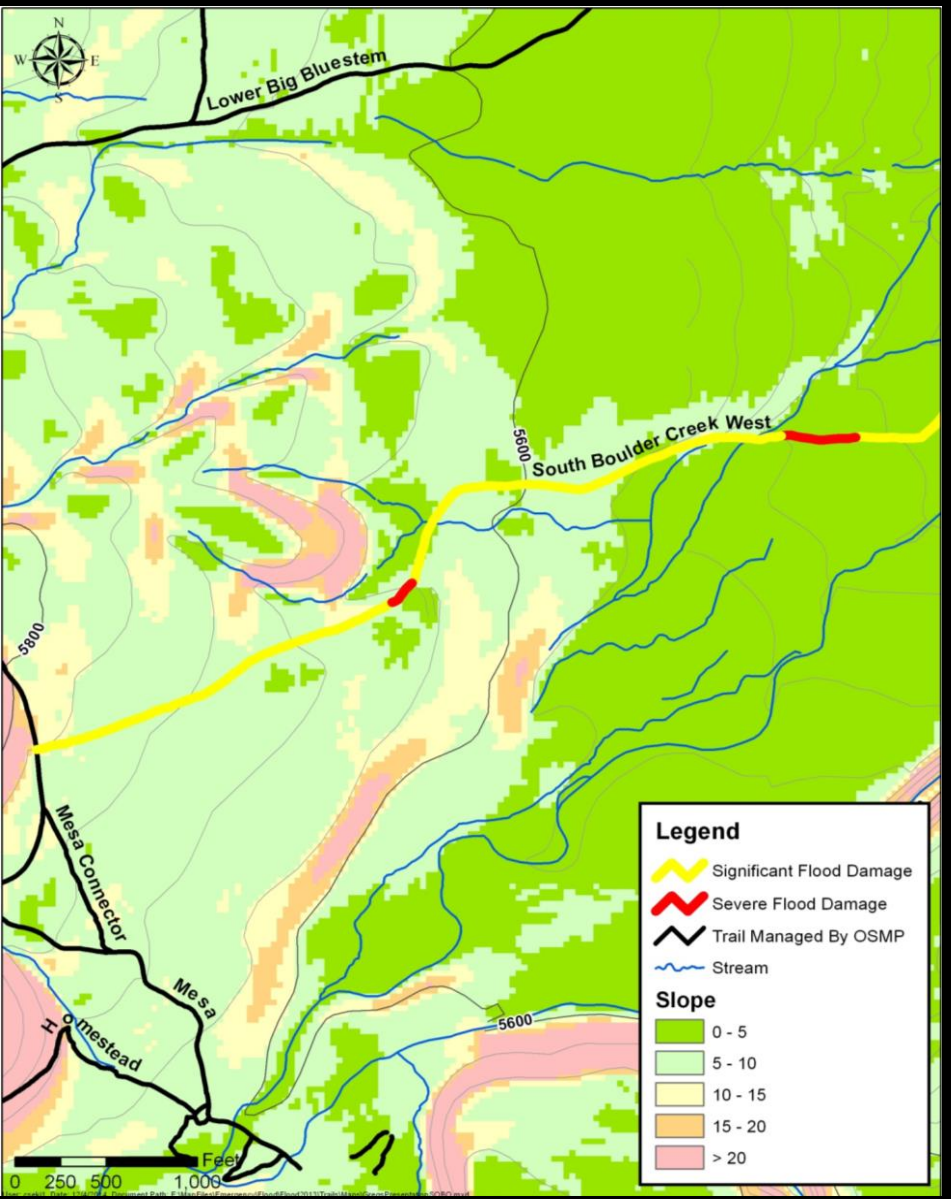
Use lots of sustainable rolling contour trail! Minimize use of the rest.

Case Study: Green Bear Trail



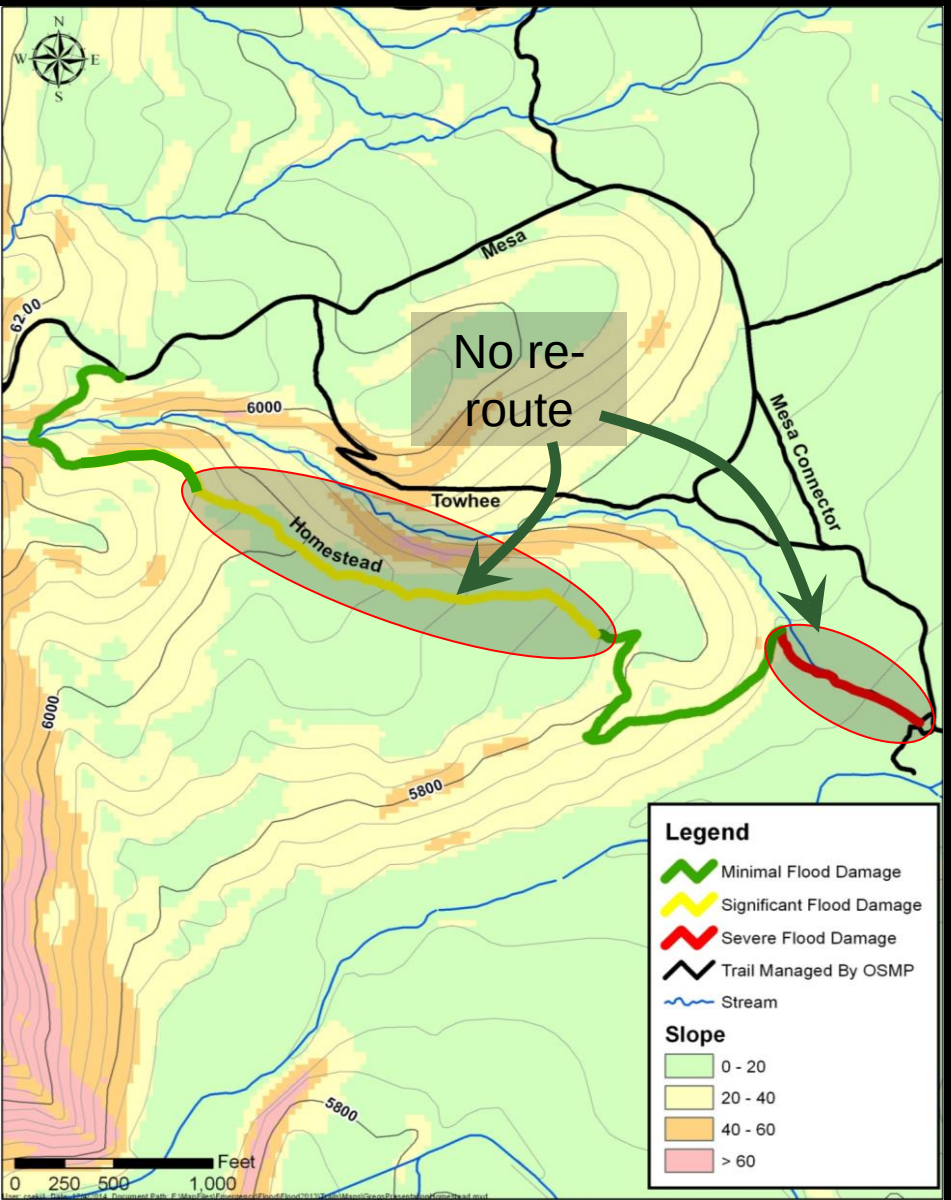
	Green Bear
Length:	7820 ft
Average Grade:	6%
Typical Cross-Slopes:	20-60%
Drainage Features:	Grade reversals, outslope
Flood Damage:	NONE

Case Study: South Boulder Creek West



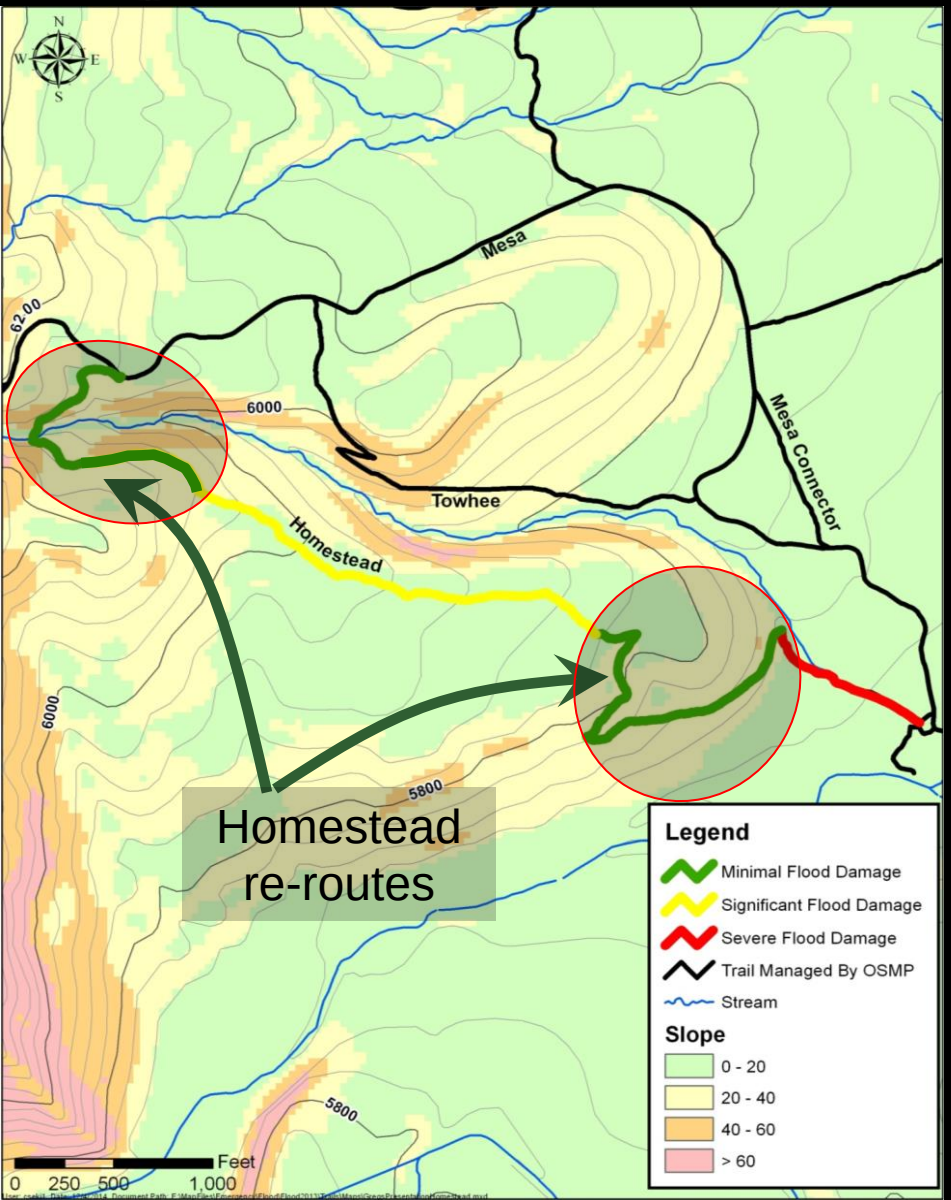
	S. Boulder Creek W.
Length:	5500 ft
Average Grade:	4%
Typical Cross-Slopes:	<10%
Drainage Features:	Waterbars, check steps
Flood Damage:	SIGNIFICANT-SEVERE

Case Study: Homestead Trail



	Homestead, no re-route
Length:	Lower: 1000 ft Upper: 2590 ft
Avg Grade:	Lower: 6% Upper: 9%
Typical X-Slopes:	<20%
Drainage Features:	Waterbars, check steps
Flood Damage:	SIGNIFICANT-SEVERE

Case Study: Homestead Trail



	Homestead re-routes
Length:	Lower: 2320 ft Upper: 1850 ft
Avg Grade:	Lower: 7% Upper: 6-10%
Typical X-Slopes:	20-40%
Drainage Features:	Grade reversals, outslope
Flood Damage:	MINIMAL

Estimated Required Post-Flood Repairs of Select OSMP Trails:

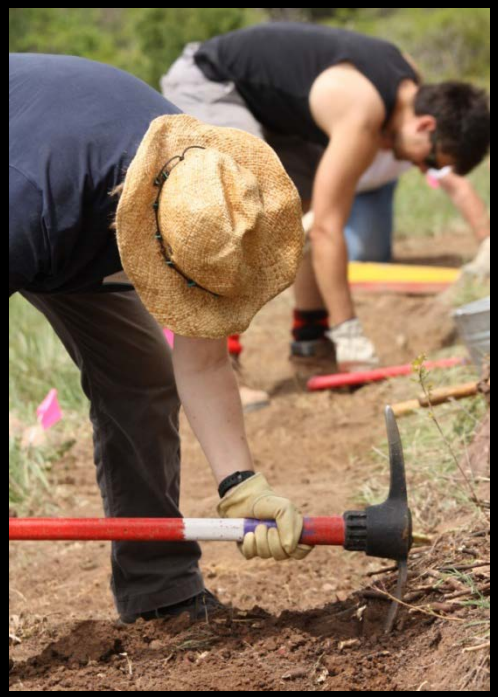
Sustainable Trails	Estimated Crew Time Post-Flood (5-person crew)
Towhee (upper)	No crew time required
Homestead (re-routed sections)	No crew time required
Green Bear	1 week
Lion's Lair (Wittemyer/Sanitas)	1 week

Unsustainable Trails	Estimated Crew Time Post-Flood (5-person crew)
Towhee (lower)	20 weeks
Homestead (not re-routed sections)	4 weeks
Saddle Rock	6 weeks
Bear Canyon	24 weeks

Where Do These Standards/Knowledge Come From?

- Annual trails conferences/trainings: PTBA, American Trails
- Collaboration with other agencies: e.g. Eldorado Canyon St. Park, VOC, Boulder County O.S., JeffCo O.S.
- Lots of on-the-ground experience
- Development of Standards & Specifications Manual

Take-Home Lessons:



- Trail design is a thoughtful multi-disciplinary process carried out by trails professionals.
- Sustainable trails weathered the flood far better than steep trails.
- Moderate grades are more sustainable.
- Sustainable trails are more cost-effective over time (by 5x - >20x).
- Some trails need to exceed sustainable criteria
  - But, do this <u>very</u> judiciously!